# Observations of the ecological impacts of Sambar *Cervus unicolor* in East Gippsland, Victoria, with reference to destruction of rainforest communities

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**Abstract**

Damage caused by Sambar, particularly browsing, antler rubbing and physical removal of particular plant species, is resulting in serious ecological consequences. Threatening processes instigated or maintained by Sambar include: loss of individual taxa, altered vegetation structure and massive widespread removal and prevention of regeneration, which is now resulting in the loss of plant communities in some areas. These observations are particularly disturbing, as it is apparent that Sambar are yet to reach their full ecological and population potential in south-eastern Australia. The destruction documented in this article is now so widespread and so severe that in places it represents an ecological disaster for specific plant and animal species, ecological vegetation classes and floristic communities. We strongly recommend that Sambar in particular, and feral deer in general, should no longer be protected under the Wildlife Act 1975, so that control methods can be devised and implemented. It now appears that such measures will be essential for the long-term survival of some fragile plant species and communities in Victoria. (*The Victorian Naturalist* **122** (4) 2005, 189-200)

## Introduction

Sambar *Cervus unicolor* were introduced into Victoria during the 1860's, and have since become the most successfully established deer species in Australia (Bentley 1978; Moriarty 2004). In Gippsland they occur throughout most habitats ranging from coastal to alpine areas, and their population and distribution is still increasing (Moriarty 2004). Sambar were first reportedly seen on the Wonnangatta River in 1951, and soon appeared in East Gippsland as they continued to move further east (Bentley 1978). In 1983, Sambar were still considered uncommon in the Gippsland Lakes Catchment (Norris *et al.* 1983). Currently, large numbers of Sambar are seen throughout East Gippsland, with their population increasing particularly in coastal and foothill country and they are now seen all year round (pers. obs. all authors). Up to 20 individual animals have been seen grazing at night on farmland adjacent to forest in the Mitchell River Catchment and on a property adjacent to the Colquhoun State Forest north of Lakes Entrance (Names withheld, pers. comm. to the authors). At Clifton Creek north of Bairnsdale, a dairy farmer shot more than 100 Sambar on his property, under permit during 2003, 18 of which were shot in one night (G Bowden pers. comm.).

Even though Sambar have been well established in Victoria for over 100 years, there have been few studies examining ecological impacts of this species (Stockwell 2003). However, the impacts of deer on the environment have been well documented overseas where introduced and native deer species are severely damaging the environment (e.g. Fuller and Gill 2001; Gill and Beardall 2001; Rooney 2001; Russell *et al.* 2001; Coomes *et al.* 2003). In early 2005 in New South Wales, the Scientific Committee made a final determination to list feral deer as a key threatening process under the *Threatened Species Conservation Act* (1995) (Scientific Committee 2005). In Victoria, a preliminary recommendation to list 'degradation and loss of terrestrial habitats caused by feral deer' as a threatening process under the Flora and Fauna Guarantee (FFG) Act 1988 (SAC 2004) has recently been rejected by the Scientific Advisory Committee (SAC in press) due to the lack of scientific evidence to validate such claims for all deer species across all of Victoria.

The purpose of this article is to highlight some observations by the authors on the severe impacts that Sambar are having on the environment in East Gippsland.

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## Methods

### *Study area*

Sambar damage was noted in 74 sites (gullies, creeks and coastal areas) visited by the authors between 2002-2005 in East Gippsland, Victoria. These sites ranged from the Mitchell River National Park in the West, to the Victorian border in the East.

### *Observational rationale*

The following rationale was used to discriminate between the effects of different browsing animals in East Gippsland, with height ranges for various types of damage listed in Table 1. This was achieved by scouring literature on the relevant animals as well as by observing animal signs in the field (see Triggs (1984) for identification of scats and footprints). The distinction between the effects of Sambar and Hog Deer *Axis porcinus* (see Table 1) was determined from locations where only one species occurs (Hog Deer – Maringa Creek, Nyerimilang: Sambar – Mitchell River National Park).

When damage to a certain individual plant was identified as being caused by Sambar, the species and particular type of damage, including the extent and severity were noted, along with the plant community in which it was growing.

## Results and Discussion

### *Sambar damage to individual plants*

Effects of browsing

Sambar are known to incorporate a wide range of native plant species into their diet (Bentley 1978; Burke 1982; Stockwell 2003), with almost all available species being consumed (Stockwell 2003; pers obs. all authors) up to a height of 2.5 m. The effects of browsing can be devastating, as Sambar have prodigious appetites, so much so that concentrated grazing and browsing can easily be seen in many different vegetation types. Browsing in the lowlands by Sambar is concentrated on particular communities, usually those of gullies, lake shores and river flats where reliable food supplies are most abundant, and elsewhere on particular species.

The most severe and obvious impacts of Sambar are related to browsing, causing death or reducing the fitness of individual plants. This is usually done by removing stems, shoots and leaves (see Fig. 1), which reduces the plant's growth rate, resulting in shorter plants that remain reachable to Sambar for longer periods, eventually leading to understorey stunting and elimination. Reproductive output of certain species can also be reduced due to consumption of flowers, fruits, seeds and seedlings (e.g. Yellow Milk Vine *Marsdenia flavescens*, Prickly Currant-bush *Coprosma quadrifida* and Muttonwood *Rapanea howittiana*).

Browsing can lead to the physical removal of shallow-rooted species (particularly ferns and epiphytes) and vegetation in general, creation of paths, removal of vine or shrub thickets that act as regeneration refuges, and prevention of natural regeneration. Such browsing comes with a range of other behaviours that is also destructive and very effective at getting foliage within reach. These include, pulling down (vines) and pushing over (tree-ferns and shrubs), and once the plant's foliage is within reach it is often browsed to death. This behaviour is particularly damaging during drought periods, especially for species such as tree-ferns which rely on the first new flush of crosiers to begin photosynthesis. It is at this point that the damage by Sambar becomes critical, as these shoots are highly favoured. Once eaten, the fern has insufficient reserves to re-shoot, and dies. Many rainforest species are subject to increased browsing pressure during drought conditions, putting the entire rainforest under increased stress, as many plants are less able to recover in dry conditions.

**Table 1.** Height (m) of various types of damage caused by Hog Deer, Sambar, and Black (Swamp) Wallabies *Wallabia bicolor* in East Gippsland. N/A = Not applicable.

| Damage | Hog Deer | Sambar | Black Wallaby |
|---|---|---|---|
| Antler damage | | | |
| Average height | <0.5 | 0.3 -1.7 | N/A |
| Max. height | 0.8 | 2.1 | |
| Browsing damage: | | | |
| Max. | 1.10 | 2.5 | 0.75 – 0.85m* |

*Stockwell (2003)

**Fig. 1.** Damage to Muttonwood by Sambar browsing from the Mitchell River National Park.

Antler Rubbing

Antler rubbing is a major problem because particular species are targeted (see also Bentley 1978) and literally rubbed to death, and with those still alive their fitness can be severely affected (Bilney unpublished data). It should be noted that trees, shrubs and vines are attacked in this manner. Antler rubbing may not completely ringbark the tree, but many trees are subject to rubbing over many years: complete ringbarking is usually the end result, and the tree is unable to heal. So widespread and ubiquitous is the damage that at the current rate of attrition, several species are under threat just from antler rubbing alone. Over 100 individual rub trees have been recorded in one patch of the rare Yellowwood *Acronychia oblongifolia* within East Gippsland Coastal Warm Temperate Rainforest. This can seriously affect not only the health of the individual plant, but the community in which it is growing. Antler rubbing often occurs in close proximity to heavily browsed areas. Antler rub marks have been noted as high as 2.1 m.

Plant species affected by Sambar

One endangered species, Buff Hazelwood *Symplocus thwaitsii*, is adversely affected by Sambar. Saplings of *S. thwaitsii* up to 5 m in height are at risk from ringbarking because of antler rubbing, whilst those less than 3 m in height are being severely browsed and some have already died. A rescue of some seedlings for removal to a deer-free environment is currently underway in co-operation with Parks Victoria.

As noted previously, there are few native species (if any) that are not browsed by Sambar. Those from East Gippsland that are the most adversely affected (primarily from observations in Warm Temperate Rainforests and wetlands) are listed in Table 2.

Of these, one is listed as endangered, four are rare, and three are vulnerable (Department of Sustainability and Environment 2005a). Two (*Symplocus thwaitsii* and Prickly Tree-fern *Cyathea leichardtiana*) are listed as Threatened under the FFG Act 1988.

It appears only a matter of time before Sambar totally eliminate some species from an area, due to preferential browsing and grazing, and concentrated effort at particular sites and within specific plant communities (e.g. Muttonwood, Fig. 2). This is having a profound impact on the survival of several plant communities in the short to medium term (Table 3). Some rare species that have limited habitat, sparse distribution, small individual population numbers and occur in preferentially browsed habitats are under immediate threat (e.g. Yellowwood and Sandfly Zieria *Zieria smithii*). Continued attention from Sambar on these species will soon see them threatened in the wild.

***Sambar damage to plant community processes and plant communities***

Destruction of regeneration refuges, leading to the failure of regeneration

Perhaps the most severe damage caused by Sambar browsing is the destruction of regenerating plant species, which alters regeneration dynamics in plant communities. With the destruction of regeneration refuges, particularly in rainforest communities, regeneration is failing to occur.

**Table 2.** Some of the more noticeable plant species severely and adversely affected by Sambar in East Gippsland. r – rare, v – vulnerable, e – endangered, FFG – Listed as Threatened under the *Flora and Fauna Guarantee Act 1988*.

| Plant Species | Notes | Observed consequences |
|---|---|---|
| **Canopy species** | | |
| Black Wattle *Acacia mearnsii* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest |
| Blackwood *Acacia melanoxylon* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest |
| Lily Pily *Acmena smithii* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest |
| r Yellowwood *Acronychia oblongifolia* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration opening up of rainforest margins, increased risk of fire entering rainforest |
| Sweet Pittosporum *Pittosporum undulatum* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest |
| Muttonwood *Rapanea howittiana* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest |
| **Shrub and tree species** | | |
| Coast Banksia *Banksia integrifolia* | Browsing | Lack of regeneration |
| Blanket-leaf *Bedfordia arborescens* | Browsing | Plants browsed |
| Sweet Bursaria *Bursaria spinosa* | Browsing | Plants browsed |
| Prickly Currant-bush *Coprosma quadrifida* | Browsing, antler rubbing | Low plants decimated, old shrubs pulled down and rubbed |
| Cherry Ballart *Exocarpos cupressiformis* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration |
| Gippsland Hemp r *Gynatrix macrophylla* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration |
| Tree Violet *Hymenanthera dentata* | Browsing | Plants browsed |
| Yellow Loosestrife v *Lysimachia japonica* | Browsing, | Plants browsed, physically removed, populations declining |
| Tree Broom-heath *Monotoca elliptica* | Browsing | Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest |
| Common Boobialla *Myoporum insulare* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration, opening up of rainforest margins, inreased risk of fire entering rainforest |
| Snow Daisy-bush *Olearia lirata* | Browsing | Plants browsed |
| Hazel Pomaderris *Pomaderris aspera* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest |
| Kangaroo Apple *Solanum aviculare* | Antler rubbing, browsing | Crowns decimated, frosts kill weakened plants in the following winter |
| Buff Hazelwood (FFG) e *Symplocus thwaitsii* | Browsing, antler rubbing | Saplings browsed to death, lack of regeneration |
| Sandfly Zieria r *Zieria smithii* | Browsing | Saplings browsed to death, lack of regeneration |
| **Vines** | | |
| Staff Climber *Celastrus australis* | Browsing, antler rubbing, pull down | Mature vines antler rubbed and pulled from the canopy, mature plants browsed, regeneration browsed to death |

Table 2. Continued.

| Plant Species | Notes | Observed consequences |
|---|---|---|
| Jungle Grape *Cissus hypoglauca* | Browsing, antler rubbing | Vine curtains destroyed, opening up of rainforest margins, loss of humidity homeostasis, increased risk of fire |
| Forest Clematis *Clematis glycinoides* | Browsing, antler rubbing, pull down | Mature vines antler rubbed and pulled from the canopy, mature plants browsed, regeneration browsed to death |
| Wombat Berry *Eustrephus latifolius* | Browsing, pull down | Mature vines pulled from the canopy, plants browsed, regeneration browsed to death |
| Scrambling Lily *Geitonoplesium cymosum* | Browsing, pull down | Mature plants browsed, regeneration browsed to death |
| Yellow Milk Vine r *Marsdenia flavescens* | Browsing, pull down | Foliage and seed pods consumed, whole plants destroyed |
| Milk Vine *Marsdenia rostrata* | Browsing, antler rubbing, pull down | Prevention of regeneration |
| Queensland Bramble *Rubus mollocanus* | Browsing, trampling | Colonies declining, previously such colonies acted as regeneration sites for palatable gap and mature canopy species |
| Small-leaf Bramble *Rubus parviflorus* | Browsing, trampling | Colonies declining, previously such colonies acted as regeneration sites for palatable gap and mature canopy species |
| Rose-leaf Bramble *Rubus rosifolius* | Browsing, trampling | Colonies declining, previously such colonies acted as regeneration sites for palatable gap and mature canopy species |
| Pearl Vine *Sarcopetalum harveyanum* | Browsing | Lack of regeneration |
| Austral Sarsparilla *Smilax australis* | Browsing, pull down | Mature plants browsed, regeneration browsed to death |
| **Tree-fern & Ferns** | | |
| Black-stemmed Maidenhair v *Adiantum formosum* | Browsing, trampling | Colonial species quickly destroyed by concentrated effort |
| Austral Lady-fern *Athyrium australe* | Browsing, trampling | Plants trampled and killed |
| Gristle Fern *Blechnum cartilagineum* | Browsing | Plants browsed |
| Fishbone Water-fern *Blechnum nudum* | Browsing, physical removal | Foliage browsed, whole plants physically pulled from the soil |
| Rough Tree-fern *Cyathea australis* | Browsing | Browsing leading to death, pushing over, populations declining |
| Prickly Tree-fern v *Cyathea leichardtiana* (FFG) | Browsing | Browsing leading to death, populations declining |
| Lacy Ground-fern *Dennstaedtia davallioides* | Browsing | Plants browsed |
| Soft Tree-fern *Dicksonia antarctica* | Browsing | Both young plants and the tallest ferns are browsed, browsing becomes critical during drought years and the death of many tree-ferns occurs at this time |
| Prickly Rasp-fern *Doodia aspera* | Browsing, physical removal | Foliage browsed, whole plants physically pulled from the soil |
| Downy Ground-fern *Hypolepis glandulifera* | Browsing | Foliage browsed, swards trampled, regrowth following drought immediately removed: at present browsing levels, whole swards likely to be destroyed |
| Shiny Shield-fern *Lastreopsis acuminata* | Browsing, physical removal | Foliage browsed, whole plants physically pulled from the soil |
| Mother Shield-fern *Polystichum proliferum* | Browsing | Plants browsed, bulbils eaten, vegetative reproduction prevented |
| **Others** | | |
| Stinging Nettle *Urtica incisa* | Browsing | Plants browsed |
| Butterfly Orchid *Sarchochilus australis* | Browsing | Removes habitat (Sweet Pittosporum branches) viz consumption of leaves removes shaded habitat and branches and orchids by breaking limbs |

Fig. 2. Muttonwood heavily browsed by Sambar, located in Dry Rainforest from the Mitchell River National Park.

Regeneration refuges include those in the form of thickets of thorny (*Bursaria spinosa*, *Coprosma quadrifida*, *Hymenanthera dentata*, *Rubus mollocanus*, *R. parviflorus*, *R. rosifolius* and *Smilax australis*) and stinging species (*Urtica incisa*), as well as tree-falls. Even plants unpalatable to most herbivores (such as *Solanum aviculare*) would normally act as a barrier and can hide more palatable species (e.g. *Acmena smithii*, *Acacia melanoxylon*).

Regeneration refuges are significant and effective barriers to native browsing species, particularly Black Wallabies, that seem to be 'effectively blind' to palatable species if they are hidden in a matrix of refuge species. In addition, Black Wallabies are particularly uncomfortable on uneven surfaces that are provided by tree-falls. As a consequence, these natural regeneration refuges have in the past been effective barriers to browsing of regeneration and have allowed natural regeneration, to occur in rainforests where small minor scale disturbances such as landslips or tree-falls can be quickly repaired.

Sambar seem impervious to thorns and stinging plants and can literally wipe them out over a number of weeks or months of concerted effort. This facilitates grazing and browsing by other species such as wallabies, Rabbits *Oryctolagus cuniculus* and Hog Deer, which are usually unable to access palatable species growing within regeneration refuges. In some cases in East Gippsland, Sambar damage has led to the contraction of specific plant communities from some sites and their replacement with grasslands dominated by exotic annuals, and even worse, bare ground. Areas of Littoral Rainforest are already being lost due to this process (Fig. 3).

In Rainforests, when a canopy tree falls, vine species entangled within the canopy usually ride with the tree to the ground. These vine species are quick to regrow, forming barriers around the tree head and form a regeneration refuge, where regenerating plants can establish in protection from native browsers. However, prior removal of vines by Sambar means such tree-fall regeneration refuges fail.

**Table 3.** Some plant communities that are severely and adversely affected by Sambar in East Gippsland.

| Floristic Community or Ecological Vegetation Class | Observed consequences |
|---|---|
| East Gippsland Foothills Warm Temperate Rainforest | Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation |
| Alluvial Terraces Warm Temperate Rainforest (Threatened, FFG Act 1988) | Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation |
| East Gippsland Coastal Warm Temperate Rainforest (Threatened, FFG Act 1988) | Loss of species, loss of structure, loss of vegetation loss of fauna refuges from predation |
| Littoral Rainforest | Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation |
| Riparian Shrubland | Loss of species, loss of structure, loss of vegetation |
| Riparian Forest | Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation; erosion |
| Estuarine Wetland | Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation; erosion |
| Sand Sheet Grassland | Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation |
| Salt Marsh | Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation; erosion |
| Swamp Scrub | Heavy browsing of species including shrubs, tree-ferns, herbs and grasses; wallows leading to loss of ground-layer plants; alteration of drainage patterns; and loss of predator refuges for ground mammals |

In addition, the size of Sambar also means that tree-falls are quickly trampled and the otherwise protective branch structure is broken down, so that physical barriers to native herbivores are also lost. Therefore growth of adult vines does not occur, and Sambar remove the potential for communities to regenerate, leading to loss of community structure, diminution of reproduction and loss of regeneration and regeneration potential. Sambar also cause the loss of seed store for gap repair and regeneration.

Habitat regenerating after fuel reduction burns is creating feeding grounds for grazing and browsing species such as Sambar, which are devastating regrowth after fire. This is also altering natural regeneration, particularly in drought conditions when the only fresh green pick is this regrowth. Logging coupes also create ideal conditions for Sambar, which graze and browse the regrowth (Bentley 1978).

***Plant communities affected by Sambar***

Those plant communities most severely affected by Sambar in the lowlands of East Gippsland are listed in Table 3. The impact of Sambar on these communities significantly increases the risk to their long-term survival. Two communities are listed as Threatened under the FFG Act 1988 (see Table 3).

***Impacts of Sambar on rainforest communities***

Rainforest communities are sparsely scattered in small pockets along gullies in East Gippsland, being restricted to certain geologies and fire-protective landforms, in areas with adequate rainfall (Peel 1999). Consequently they are often no larger than a few hundred metres long, often less than 100 m wide. Being relatively small in the context of other plant communities, and containing a large proportion of palatable species, rainforests provide preferred living environments for Sambar, and as a consequence are suffering severe damage mainly due to browsing and antler rubbing. Several rainforest communities occurring in East Gippsland and southern New South Wales are therefore under serious threat as a direct result of Sambar damage (see Table 3).

Serious threats include alteration and deflection of rainforest successional dynamics at all levels, with pioneer to mature phase species killed or prevented from regenerating. With a lack of regeneration, soils can become degraded due to

**Fig. 3.** Failed gap regeneration and loss of Littoral Rainforest as a result of Sambar damage.

exposure to the sun (negative feedback loops, as seen in Fig. 3). This can lead to a disruption of internal rainforest moisture homeostasis through loss of vine thickets and curtains, canopy tree curtains, loss of understorey shrubs and regeneration, expansion of gaps due to destruction of regenerating plants; all of which lead to increased risk of fire and loss of rainforest. In many circumstances, browsing can lead to the loss of all regenerating individuals in an area, leaving only dead stalks of once healthy plants. Regeneration is failing in many rainforest stands across East Gippsland, and in areas that are regularly occupied by Sambar, this regeneration process is not occurring. In concert with antler rubbing, it seems certain that major tracts of rainforest are under threat of soon being lost from Victoria due to Sambar damage.

This threat upon rainforest in East Gippsland is also likely to affect fauna dependent on this habitat type, be it for roosting, nesting or foraging. The occurring of Warm Temperate Rainforest in Gippsland is at the edge of its biogeographical range (Peel 1999), and is also the most southerly limit of some migratory bird species, that rely on nectar and fruit resources mostly found in rainforest (e.g. Topknot Pigeon *Lopholaimus antarcticus* (Blakers *et al.* 1984; Barrett *et al.* 2003)).

***Other ecological implications of Sambar occupation***

Creation of paths

Sambar develop regularly used paths through even the thickest vegetation. Whilst the physical damage is not spatially large, paths serve to concentrate Sambar activity in the most favoured environments (particularly gullies). Perhaps the biggest impact is the fact that paths created by Sambar essentially become highways through the bush for introduced predators which use paths as movement corridors (May and Norton 1996; Claridge 1998). This fragmentation of the understorey allows introduced predators to gain access into areas of previously dense scrub or ground cover. These factors, along with the destruction of refuges, are likely to have a major impact on native animal pop-

**Fig. 4.** A Sambar wallow in Salt Marsh from Lake Tyers.

ulations, particularly small terrestrial mammals which rely on dense vegetation as a refuge from predators (Catling and Burt 1995; Claridge and Barry 2000).

When contemplating accessing a steep gully, gorge, or crossing a creek normally impassable because of dense vegetation, all you need to do is look for a Sambar trail and follow it to your destination. Access into areas of difficult terrain has become far easier in recent years primarily due to the presence of Sambar. Sambar are known to keep existing tracks open (Bentley 1978).

Wallows

Sambar choose areas of shallow water with a muddy base, often in a secluded position, to wallow. Wallows also provide a focus for Sambar activity, and physical damage to plants is more severe in the vicinity of the wallow (also see Bentley 1978). Vegetation is usually physically removed from around wallows rather than by browsing. Wallows have been noted in Swamp Scrub, Warm Temperate Rainforest, Salt Marsh (Fig. 4) and Estuarine Wetland.

Rutting areas

These areas are most likely related to rutting males during the breeding season. At these sites vegetation is completely cleared, mainly by trampling and physical removal, resulting in bare ground. Patches of bare soil up to 7 m in diameter have been observed on gully floors of Alluvial Terraces Warm Temperate Rainforest (Fig. 5), with surrounding vegetation also being rubbed and browsed. Along floodplains of small creeks, areas over 15 m long have been completely cleared amongst bracken fern, resulting also in bare ground. Such areas in the core of rainforest become sites for weed invasion and degradation of otherwise healthy and intact rainforest stands. Weed invasion is a well documented threat to the survival of many communities of Warm Temperate Rainforest.

Erosion

Erosion is becoming an issue as Sambar move down into the lowlands and begin to graze wetlands, with or without the presence of Hog Deer. The removal of swamp or riparian vegetation by these species is leading to bank exposure and erosion. Sambar, being much larger than Hog Deer, are able to wade out further and destroy plants in deeper water or mud. Those areas that are suffering the most from erosion are Estuarine Wetlands (*Phragmites/Bolbo-*

**Fig. 5.** A Sambar rutting area in Alluvial Terraces Warm Temperate Rainforest from Lake Tyers.

*schoenus* dominated) whose position along lake shores makes them more vulnerable to wave action once these fringing species are wiped out. The loss of these fringing wetlands is also degrading habitat of fish and other aquatic species and is mobilizing phosphorous-rich sediments. The sediment mobilization is likely to lead to more frequent and severe blue green algal blooms in these estuaries (Boulton and Brock 1999; Price and Lovett 2002). Much of the fringing wetlands around the Gippsland Lakes have been removed through domestic stock grazing. Significant efforts are now underway to fence stock out of such waterways. However, Sambar are capable of easily jumping over standard stock fences. Increased erosion is also likely in Riparian Shrublands, which are a focus of significant browsing attention from Sambar.

Wallows and rutting areas also create increased erosion, as they are usually in low lying areas such as in creek beds which are vulnerable to gully erosion during rainfall events.

A food source for predators

Although it is unlikely that wild dogs *Canis familiaris* kill many adult Sambar, they will kill juveniles and scavenge carcasses left behind by hunters (Bentley 1978; pers. obs.). From April to September there is significant Sambar hunting in many catchments of the Gippsland Lakes, with increased hunting effort now occurring (especially within the past decade) east of the Snowy River, as Sambar's range expands inexorably eastward and northward. This hunting is in the form of stalking, hound teams and spotlight shooting. Many hunters who seek a trophy head, or select cuts of venison, leave behind most of the carcass after a successful kill. Some hound teams will also dump multiple carcasses that are of little value to them in the one location (one author observed five carcasses in three dumps, in the winter of 2003, in the Bairnsdale area). Carcasses that are dumped are generally completely scavenged by wild dogs. As of April 2004, the number of licensed deer shooters in Victoria was approximately 12 000, with in

excess of 8500 Sambar being harvested per year (Department of Sustainability and Environment 2005b). Although there is no data on the proportion of each Sambar carcass that is left behind in the forest, it seems reasonable to assume that several hundred tonnes of Sambar remains are left behind per year, resulting in a substantial and reliable food resource for wild dogs.

The height of Sambar hunting also corresponds with the birth and weaning of wild dog pups (Menkhorst 1995), and this provides a significant food source at a crucial time for the survival of juvenile wild dogs. A peak in Sambar calving also occurs during winter (Bentley 1978; Menkhorst 1995), providing wild dogs with easily killed prey. Anecdotal evidence from wild dog trappers from the 1940's to 1960's (E V Ellis and L Lees) strongly suggests that in the past, many young dogs perished at the end of winter/early spring due to a lack of food. Increased access to reliable food supplies during critical reproductive periods for wild dogs may be leading to improved survivorship and larger numbers of wild dogs in these areas. This may have devastating effects, particularly on small mammal populations and livestock. From faecal pellet counts in the Upper Yarra Catchment, it has been estimated that Sambar were 100 times more abundant than Black Wallabies (Houston 2003; Stockwell 2003), which may be due to competition from Sambar as well as predation by wild dogs. From 30 wild dog scats collected during late spring and early summer in the Yarra Ranges National Park, Sambar were recorded in six scats all collected in late spring (Anon. 2001).

Hunters in North America are required by law to completely salvage remains of all large game animals (other than visceral contents) that are shot (Alaska Department of Fish and Game 2004). One justification for this law is to avoid artificially affecting the population balance of predators (Wolf, Bear, etc.) over prey. This suggests that one of the prime reasons that we have large numbers of wild dogs in eastern Victoria may be due to the lack of regulations requiring hunters to remove carcasses from the forest.

**Conclusion and Recommendations**

Damage caused by Sambar on the Australian environment will spread far beyond those areas mentioned in this paper, as this species is yet to reach its full ecological or population potential. Even at current population levels and geographic extent, a large number of ecological processes in forested ecosystems are in decline, being disrupted or destroyed. Sambar are not only capable of damaging and killing individual plants, they are capable of significant, severe and possibly lasting alteration to vegetation structure, including negative feedback loops that lead to destruction of particular vegetation types such as rainforest and wetlands. With such destruction, Sambar are currently a major threat to many plant species and communities in East Gippsland, and are likely to adversely affect many native animals associated with such habitats.

With the Sambar population still increasing, and yet to reach its full ecological potential, appropriate immediate action is of the upmost importance. In order to control Sambar, they need to be regarded as a pest species, and should no longer be protected under the Wildlife Act 1975, so control methods can be readily implemented without permit and at any time of year. We stress the importance for long-term Sambar control across all land tenures as well as in vulnerable areas, including National Parks, to try to reduce this direct threat to fragile habitats. It is imperative that the management of Sambar be updated to try to increase the number of animals harvested per year, instead of allowing them to reach high population densities. Current restrictions on hunting methods are contributing to an overabundance of Sambar, and significantly impeding sound ecologically-based feral deer management in Victoria. One method of increasing the number of Sambar killed is to legalise spotlight hunting. Spotlight hunting is currently prohibited because it is seen by traditional hunters as being unethical, potentially 'reducing hunting opportunity for law-abiding hunters' (Department of Sustainability and Environment 2005b). Consequently it is also recognized that reputable and ethical hunters and hunting organizations are an

integral part of the solution for controlling these alien and pest species in the Australian landscape.

Another recommendation is that legislation allowing hunting for trophy animals be changed, so that all remains are removed, except for visceral remains, to try and reduce a possible imbalance of wild dog populations in many areas.

It is essential that long-term ecological studies be conducted into the damage that Sambar, and other species of deer, are having on the environment. It has been a major failing of our governments not to have recognised, or even assessed, the impact that Sambar have had on the environment. Land managers including the Department of Primary Industries (DPI), Department of Sustainability and Environment (DSE), Parks Victoria and landholders need aecess to the full suite of eontrol methods for these species, so they can be implemented as soon as possible, before Sambar populations reach their potential, and before irreversible damage is done to larger areas of forest and wetland ecosystems.

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